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Région de l'Ouest et du Nord

REPORT ON PERIPHYTON PRODUCTIVITY IN THE QU'APPELLE RIVER, 1980 TO 1981

DECEMBER, 1985

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ENVIRONMENT CANADA
WATER QUALITY BRANCH
REGINA, SASKATCHEWAN

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The opinions and conclusions expressed are those of the author and are not necessarily those of the Water Quality Branch.

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1.0 SUMMARY AND RECOMMENDATIONS

Periphyton samples were collected from two sites on the Qu'Appelle River, above and below the Qu'Appelle Fishing Lakes, using artifical substrates during the open water months of 1980 and 1981. Estimates of periphyton productivity were made by analyzing biomass accumulation as chlorophyll-a and ash-free weight. The results of these analyses show that the productivity was highly variable with time and was much higher at the site downstream of the Fishing Lakes than upstream. Numerous regression analyses were preformed on the productivity data and the nutrient and physical data generated as part of a nutrient loading study (Munro, 1985). Good correlation could not be found between the productivity data and the water quality variables based on the regression analyses.

Based on the results of this study, it is recommended that the Water Quality Branch not consider implementing the use of periphyton productivity, as described in this study, to assess productivity on a routine basis, especially in nutrient rich streams where productivity is high. However, their use in nutrient poor streams or in special studies should not be ruled out on the basis of this study.

2.0 INTRODUCTION

Periphyton are the major primary producers in many flowing waters. As these organisms are not equipped with a means of procuring the essential elements from the stream bed, their productivity is closely related to the characteristics of the water mass flowing by. This fact has resulted in periphyton being used to assess water quality of streams on numerous occassions, (Northcote, et al., 1975, Patrick, 1973, Collins and Weber, 1978 and Peterson, et al., 1983).

During the summers of 1980 and 1981 the Water Quality Branch undertook a study to examine periphyton productivity in the Qu'Appelle River, above and below the Fishing Lakes (Figure 1). In addition, the study provided an opportunity to evaluate the potential use of periphyton productivity information for assisting in the routine measurement and assessment of aquatic quality as part of a biomonitoring program.

The Qu'Appelle River was selected as the study site because of the high nutrient levels known to occur there which have resulted in excessive algae growths in the lakes along the system (Qu'Appelle Basin Study, 1972). In addition, as part of another study, the Water Quality Branch was conducting extensive nutrient assessment at the same sites on the Qu'Appelle River (Munro, 1985), thereby allowing complementarity.

2.1 Study Area

The Qu'Appelle River Basin extends approximately 400 kilometres from its headwater near Lake Diefenbaker to its confluence with the Assiniboine River, and drains an area of approximately 52,000 square kilometres (Qu'Appelle Basin Study Board, 1972). The Qu'Appelle River is a mature river having a broad flood plain and well developed meanders. The river flows through seven lakes, (Figure 1) these being Buffalo Pound Lake, the Fishing Lakes (Pasqua, Echo, Mission and Katepwa), Crooked Lake and Round Lake. Last Mountain Lake discharges into the Qu'Appelle River through Last Mountain Creek. Water also enters the Qu'Appelle River system from the South Saskatchewan River by a diversion channel from Lake Diefenbaker.

There are numerous minor tributaries to the Qu'Appelle River and about ten major tributaries, of which Moose Jaw River and Wascana Creek are the most significant. The tributaries generally have their highest flows during the spring runoff, with little or no flow during the remainder of the year. During these low or no flow periods, river reaches often become plugged with vegetation.

The climatic conditions in the Qu'Appelle Basin are characterized by hot summers, cold winters and moderate precipitation. Mean precipitation ranges from 350 to 420 millimetres within the basin of which about 25 per cent occurs as snow (Qu'Appelle Basin Study Broad, 1972). Variation in

Qu'Appelle River Basin

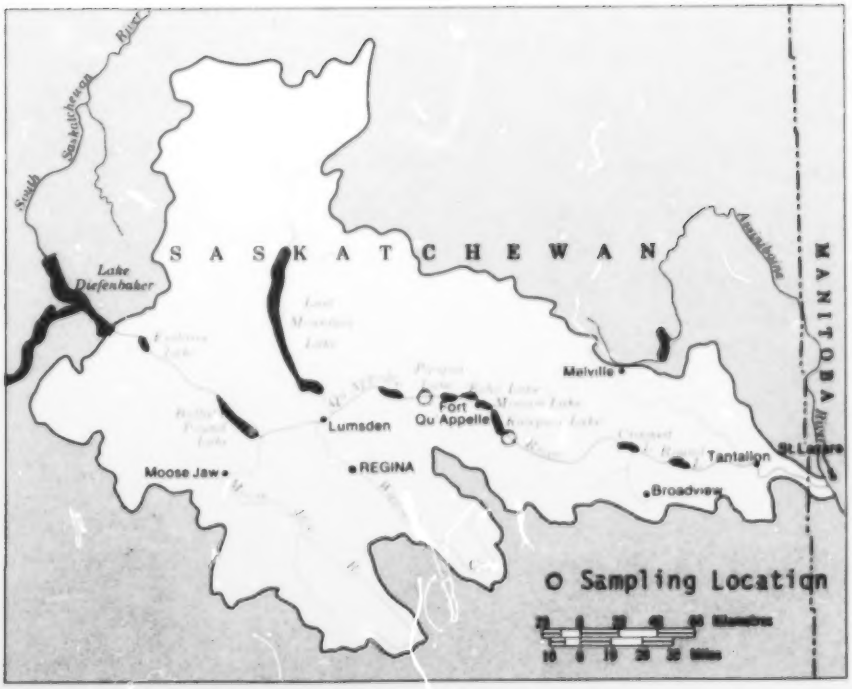

Figure 1. Qu'Appelle River Basin showing sampling locations.

precipitation alters the drainage area of the Qu'Appelle River dramatically due to the relatively flat land. The drainage area in a dry year may only be 50 per cent of a wet year (Tones, 1981). Drought conditions also result in higher ratios of effluent volume to receiving surface water volume thus elevating nutrient concentration during these low flow periods.

The Qu'Appelle River provides water for municipal and industrial uses, agriculture (irrigation and livestock watering), recreation and wildlife habitat. The major portion of the Basin is agricultural, in particular, cereal grain cropping; however, a substantial number of small livestock operations exist throughout the basin. The large urban centres, Regina and Moose Jaw, are the major users of the Qu'Appelle River water. These cities draw their municipal water supply from Buffalo Pound Lake and discharge their sewage effluents into Wascana Creek and Moose Jaw River, respectively. Since 1972, considerable effort has been spent in an attempt to reduce the nutrient loading to the river. Livestock operations have been relocated and/or practices improved. Regina upgraded its sewage treatment to tertiary treatment in 1976, effectively removing 80 to 85 per cent of the total phosphorus as well as removing algae (Tones, 1981). The city of Moose Jaw is in the process of introducing spray irrigation for its sewage treatment.

3.0 METHODS

Periphyton productivity was examined by determination of accumulation of periphyton biomass, as ash-free weight and chlorophyll-a, on an artifical substrate for various periods of time. Periphyton samples were collected between May 27 and November 12, 1980, and between April 21 and October 27, 1981, at two locations on the Qu'Appelle River (Figure 1). One location above thé the Fishing Lakes, Qu'Appelle River above Pasqua Lake, was 21 kilometres upstream of Pasqua Lake (Prairie Farm Rehabilitation Administration, 1980). The second, Qu'Appelle River below Katepwa Lake, was about 0.5 kilometres downstream of the control structure at the outlet of Katepwa Lake.

The substrates used were 25 x 100 x 3 millimetre plexiglass plates supported on edge in a floating holder similar to that described by Patrick et al., (1954). Each holder held 12 plates and floated so that the plates were held 10 centimetres below the water surface. Three holders were placed in the water at 21 day intervals. At seven day intervals after introducing the substrates to the stream, one holder was removed and the colonizing periphyton collected from the plates, thus producing samples with 7, 14 and 21 day accrual periods.

Each plate was carefully scraped with a one sided razor blade to remove the periphyton from the two flat sides of the plate and the periphyton placed in glass vials. These samples were randomly divided into two groups, for chlorophyll-a and

ash-free weight analysis. The samples for chlorophyll-a analysis were preserved with 100 per cent methanol (which was stored over magnesium carbonate to remove any possible acid residues) then sealed against leakage and held in the dark until analyzed. Chlorophyll-a analyses were conducted by the Department of Fisheries and Oceans at the Freshwater Institute in Winnipeg, Manitoba. Samples were extracted with methanol and chlorophyll-a determined by fluorometry. The results are not corrected for phaephytin. The samples for ash-free weight were placed in deionized water, refrigerated and delivered to the Regina, Water Quality Branch field laboratory. The samples were immediately placed in a drying oven (within six hours of collection). Ash-free weight was determined by subtracting the ash weight (500 degrees C) from the dry weight (105 degrees C) of the sample, following the methods outlined in Standard Methods, Section 1003-4 (American Public Health Association, 1980).

4.0 RESULTS AND DISCUSSION

The results of the periphyton analyses are shown in Figures 2 to 5. These figures show a wide variation in periphyton productivity throughout the study, both temporally and spatially.

Periphyton productivity is affected by many factors including: availability of light, solar incidence,

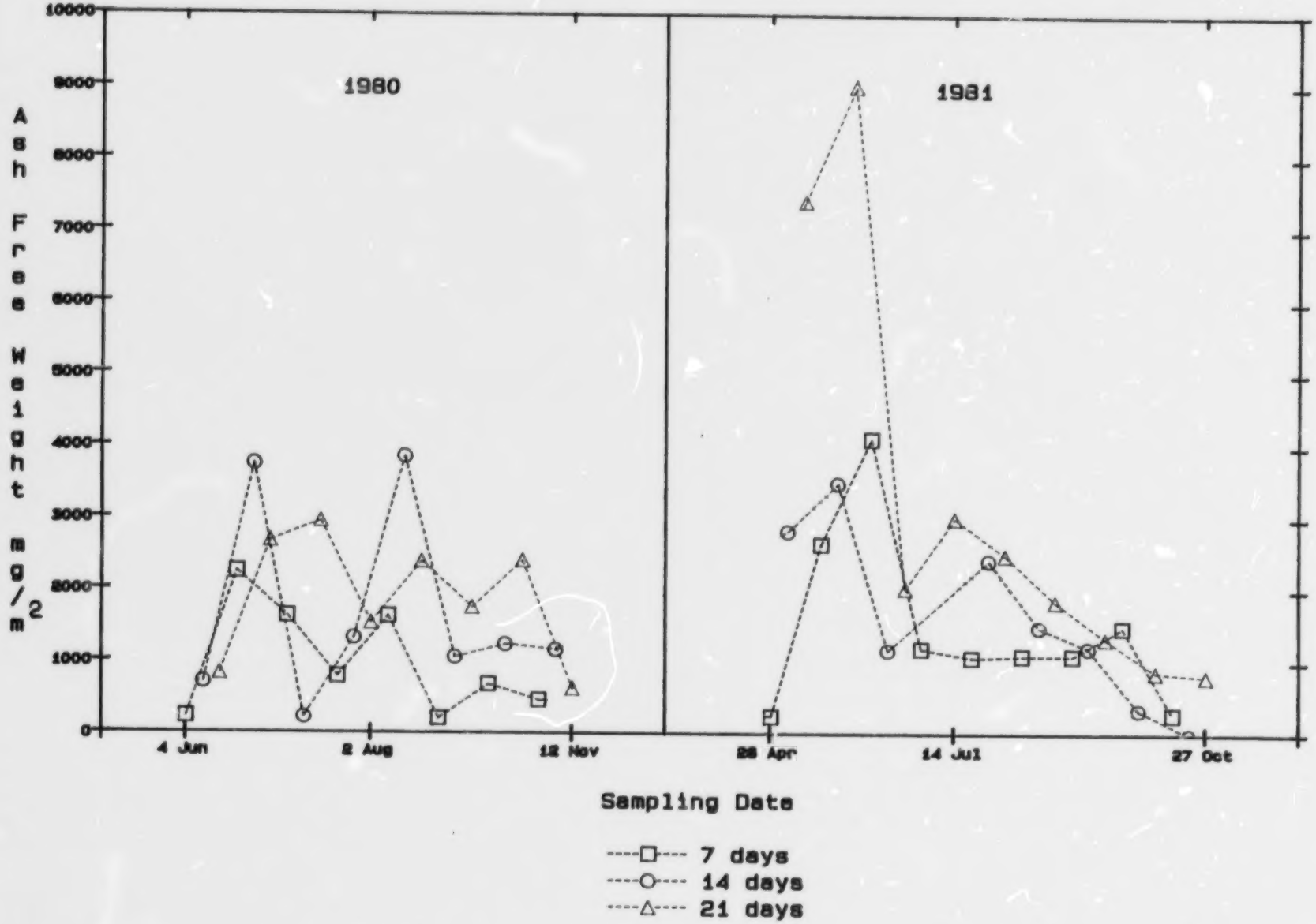

Figure 2. Biomass as ash-free weight in the Qu'Appelle River above Pasqua Lake.

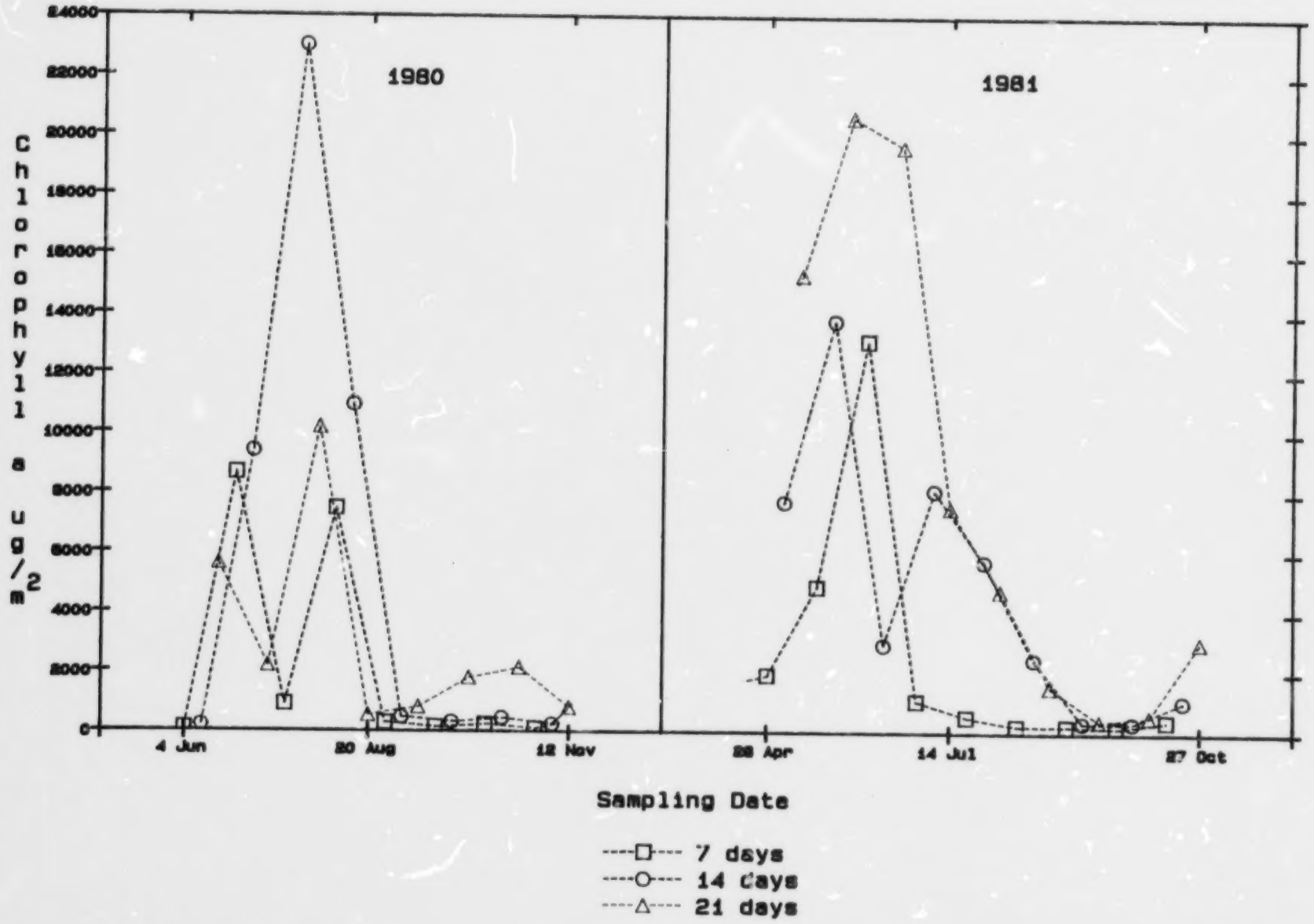

Figure 3. Biomass as chlorophyll-a in the Qu'Appelle River above Pasqua Lake.

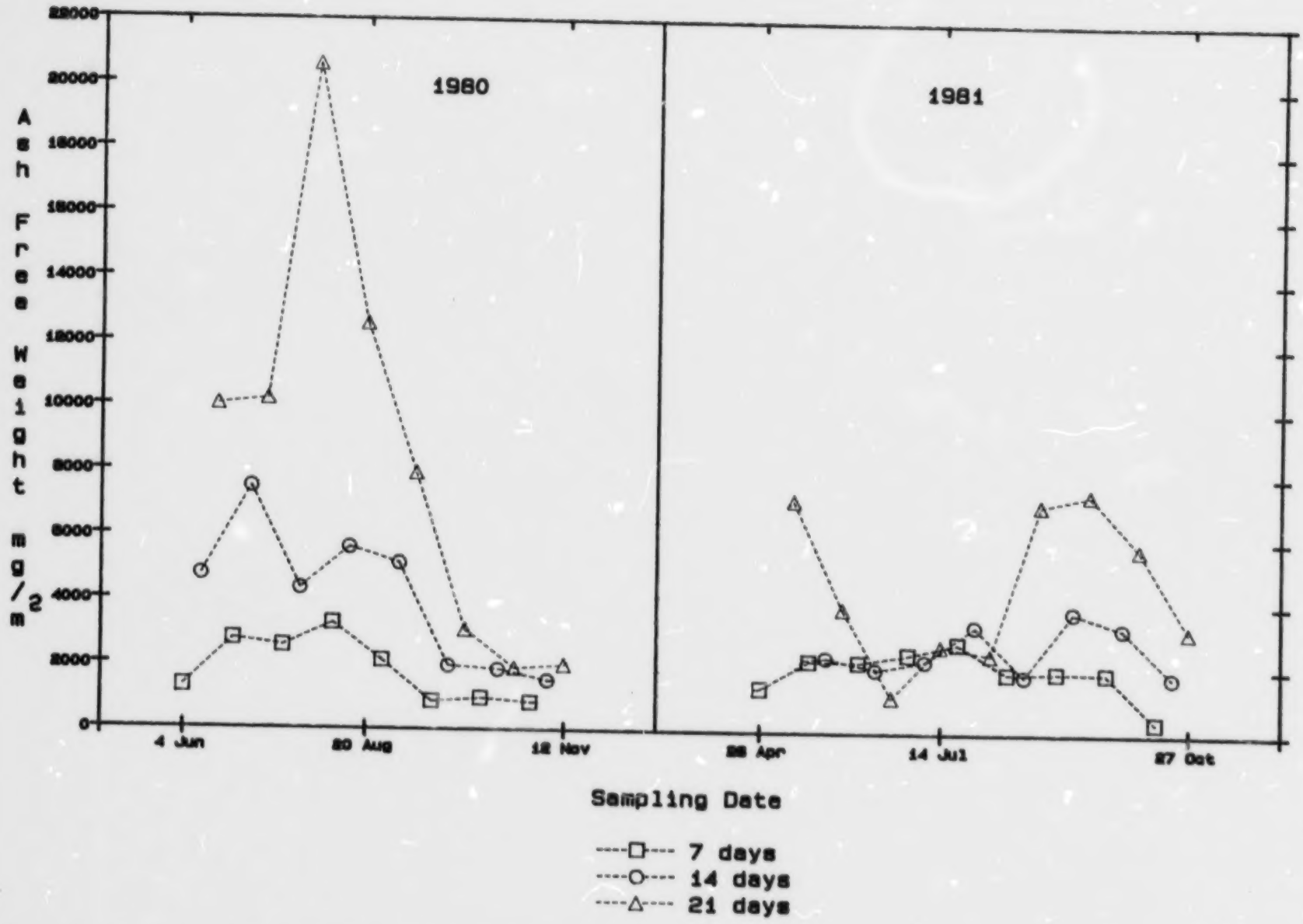

Figure 4. Biomass as ash-free weight in the Qu'Appelle River below Katepwa Lake.

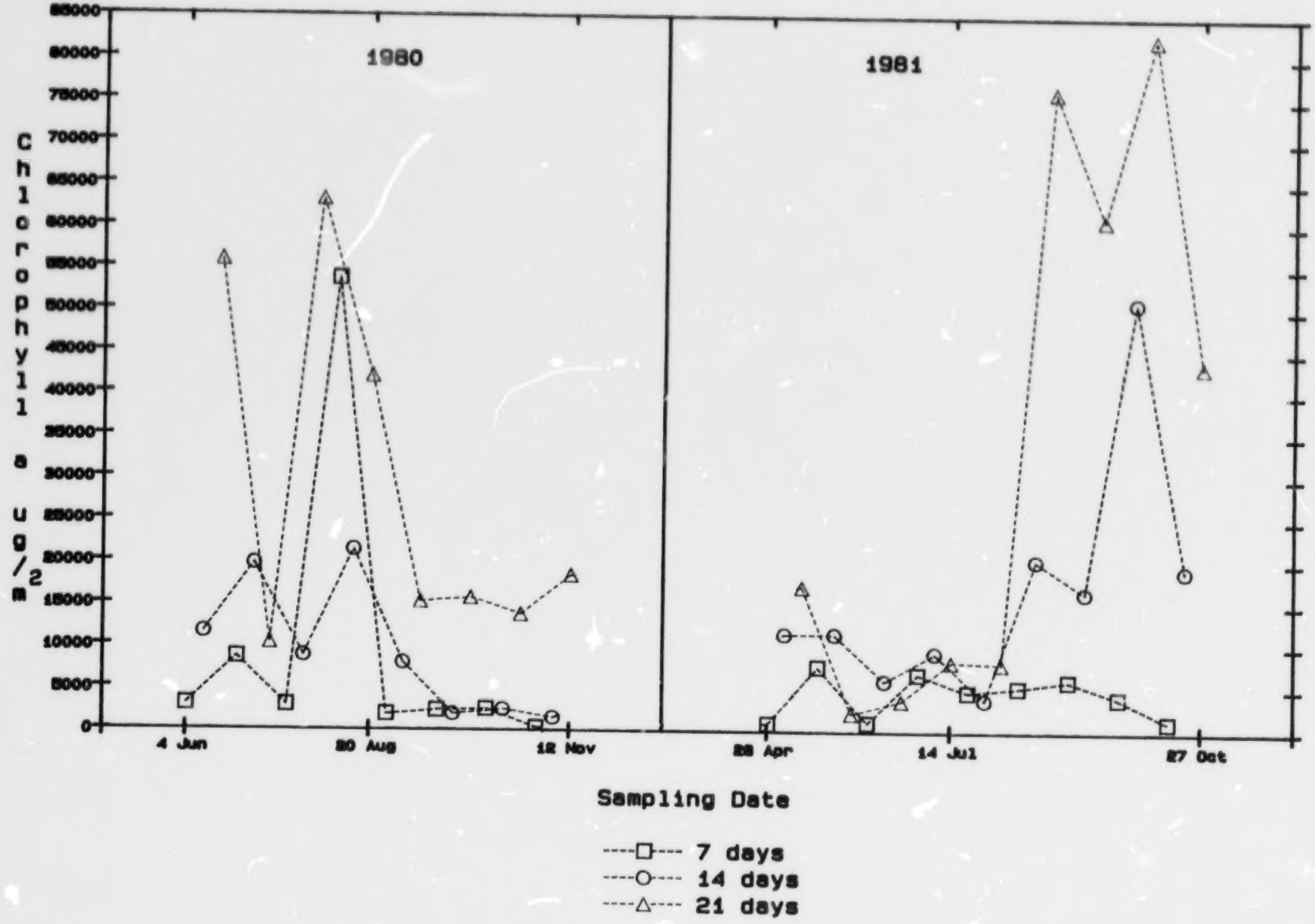

Figure 5. Biomass as chlorophyll-a in the Qu'Appelle River below Katepwa Lake.

transparency, and turbidity; substrate type, condition, location, depth and availablity; water movement, current and velocity; pH, alkalinity, and hardness; nutrients (eg. nitrogen, phosphorus and carbon); other dissolved materials (eg. calcium, sulphur, and silica); metals and trace elements; and temperature, oxygen and carbon dioxide (Weitzel, 1979). Of these factors it is arguable that light and nutrients are of most importance.

The greatest productivity at the site above Pasqua Lake, based on the chlorophyll-a data, occurred in June and July, in both 1980 and 1981. The ash-free weight data showed similiar high growth periods in 1981, but in 1980 the early summer productivity was only slightly higher than the other sampling periods. At the downstream site, below Katepwa Lake, the chlorophyll-a data and the ash-free weight data show similiar trends in 1980 both peaking about the end of July. In 1981 the chlorophyll-a data peaked in the late summer and through the fall. The ash-free weight data also increased in the late summer and fall but the magnitude of the increase was much smaller than seen in the chlorophyll-a data.

Comparision of the biomass data from the two sites shows that the site below Katepwa Lake had much higher productivity throughout the entire study period. Average biomass as chlorophyll-a and ash-free weight were approximately five and two times higher, respectively, at the downstream site. This difference in the productivity between the two locations can be

explained to a large extent by physical and chemical differences. At the upstream site there was a large suspended sediment load which greatly reduced the transparency of the water. Much of the suspended sediment load was deposited in the Fishing Lakes, resulting in a higher level of transparency and therefore greater potential for growth at the downstream site. The total nutrient concentrations (phosphorus and nitrogen) at the site above Pasqua Lake were significantly higher then below Katepwa Lake during this study (Munro, 1985). Particulate phosphorus and nitrogen represented 82 and 61 per cent of the total phosphorus and nitrogen, repectively, at the site above Pasqua Lake. At the site below Katepwa Lake the proportion of the total phosphorus and nitrogen represented by particulate forms were 17 and 22 per cent, respectively. Although some particulate phosphorus and nitrogen is potentially available to plants, especially when nutrients levels are low, the dissolved forms are generally more available. The dissolved phosphorus at the site below Katepwa Lake was about three times higher than at the upstream site and dissolved nitrogen about one half that of the upstream concentration. This higher potentially available phosphorus and nitrogen at the site below Katepwa Lake also suggests that the productivity should be greater at the downstream site.

Visual observation at the time of sample collection confirmed that productivity was higher at the site below Katepwa Lake. At the upstream site, above Pasqua Lake, plant growth in

the river was limited and restricted for the most part to near shore growth of emergent plant species. Below Katepwa Lake both emergent and submerged plant species were abundant. In late summer rooted submerged plants and filamentous algae growth was dense across the entire river channel.

In an attempt to determine if the productivity could be linked to one or a number of nutrient or physical variables, numerous regression analyses, including linear, polynomial and multiple regression, were performed on the biomass data and the nutrient and physical data collected as part of the nutrient loading study (Munro, 1985). None of these regression analyses showed consistant significant correlation between biomass accumualtion (ash-free weight or chlorophyll-a) and the nutrient or physical parameters. Based on these analyses it is not possible to show good correlation between periphyton productivity at the two sites on the Qu'Appelle River and nutrient concentrations (total, particulate and dissolved phosphorus and nitrogen and nitrite-nitrate) or physical variables (water temperature, pH, conductivity, turbidity, or nonfilterable residue) or any combination of these variables. Thus, suggesting that other unmeasured variables are having a greater effect on periphyton than those examined in this study.

The inability to relate productivity to routine water quality variables makes it impossible to draw conclusions regarding variables which maybe controlling periphyton productivity in the Qu'Appelle River. The biomass data have

only shown that productivity was higher at the downstream site, a finding that could have been simply determined by a visual site inspection during the summer months. As a result the usefulness of the measurement of periphyton productivity as a routine monitoring tool for the Water Quality Branch is reduced. The difficulty in relating productivity to water quality variables, particularity nitrogen and phosphorus, maybe a function of the very high levels of these nutrient in the Qu'Appelle River resulting in other variables limiting periphyton growth. Other studies (Peterson, et al., 1983 and Tilley and Haushild, 1975) have shown productivity was related to nutrient levels in streams with low concentrations of nutrient.

ACKNOWLEDGEMENTS

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